

HEAT PUMP REVERSING VALVE APPLICATION

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INTRODUCTION

When the Arab nations cut back on oil exports (late 1973), it became apparent to the free world what scientists had known for years, i.e., that fossil fuels will eventually be depleted and thus energy-saving devices must be put into use immediately, and new sources of energy be made available as soon as possible.

To this end the Refrigeration and Air Conditioning Industry came forth immediately and informed the Federal Government that they had one such energy saving machine! The "Heat Pump" was then described as a device that could under certain conditions deliver 3 times as much heat energy as it took to operate itself. This is in contrast to a modern hot air gas-fired furnace which under the best of conditions will deliver only 7/10 or 70% of a heat energy unit for each one unit expended to operate itself.

With the blessing of the various energy conservation agencies (Federal Government) and a growth factor of 200-300% reported each year by heat pump manufacturers there is no doubt of an immediate demand for competent service engineers as there is not enough to keep up with the accelerated growth pattern.

Let us now look into the heart of a reverse cycle heat pump system and observe the one main difference in hardware between it and a conventional air conditioner. The term "Heat Pump" can be applied to any refrigeration system since the basic function of a refrigeration system, is the transfer (pumping) of heat from one medium to another. Figure 1 shows a basic compression refrigeration cycle, consisting of a compressor (a "pump") two heat exchangers (condenser and evaporator) and an expansion device. After the low pressure gas returns from the evaporator, it is "pumped" by the compressor to a high level of pressure and temperature. As it flows through the first heat exchanger (condenser), it is condensed to a liquid under high pressure by rejecting heat through the condenser to the surrounding medium, which, for example, may be air or water. The high pressure liquid then flows through the expansion device, expanding it to a mixture of liquid and vapor at a low pressure and temperature. This mixture flowing through the second heat exchanger (evaporator) and absorbing heat from its surrounding medium is evaporated to a low pressure gas. Finally, the low pressure gas returns to the pump, and the cycle is repeated. Thus, the system transfers heat from one medium to another.

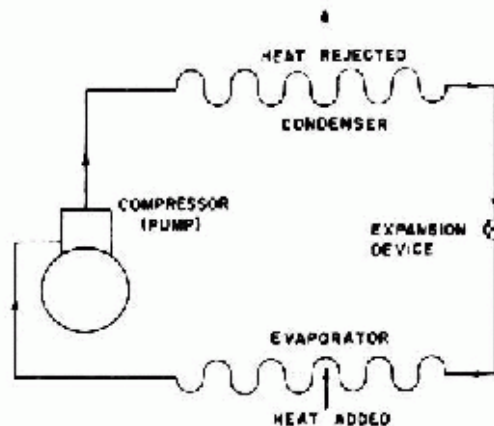


Figure 1

Basic compression refrigeration cycle

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In order to utilize the above basic cycle for either heating or cooling the same medium, it becomes necessary to modify the simple system shown in Figure 1. The most commonly used modified system to accomplish this purpose is known as the "Reverse Cycle Heat Pump."

The first of these systems was installed with a number of hand valves necessitating manual operation when it was desired to reverse the system. Figure 2 shows a schematic diagram of such a system.

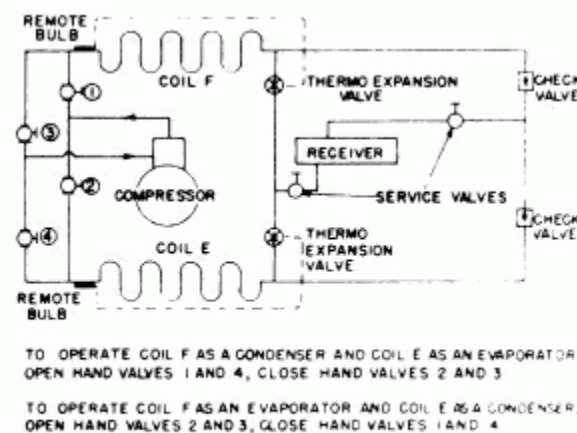


Figure 2

Manually operated reverse heat pump system

With valves 1 and 4 open, 2 and 3 shut, coil F is the condenser and coil E is the evaporator. Closing valves 1 and 4 and opening 2 and 3 you now have coil F acting as an evaporator and coil E becomes the condenser. Thus by the action of four independent hand or solenoid valves the basic refrigeration system has been "reversed!"

The next step was the development of a fully automatic reversing system. This was made possible by the introduction of 3-Way and 4-Way Reversing Valves, which made the reverse cycle heat pump commercially attractive.

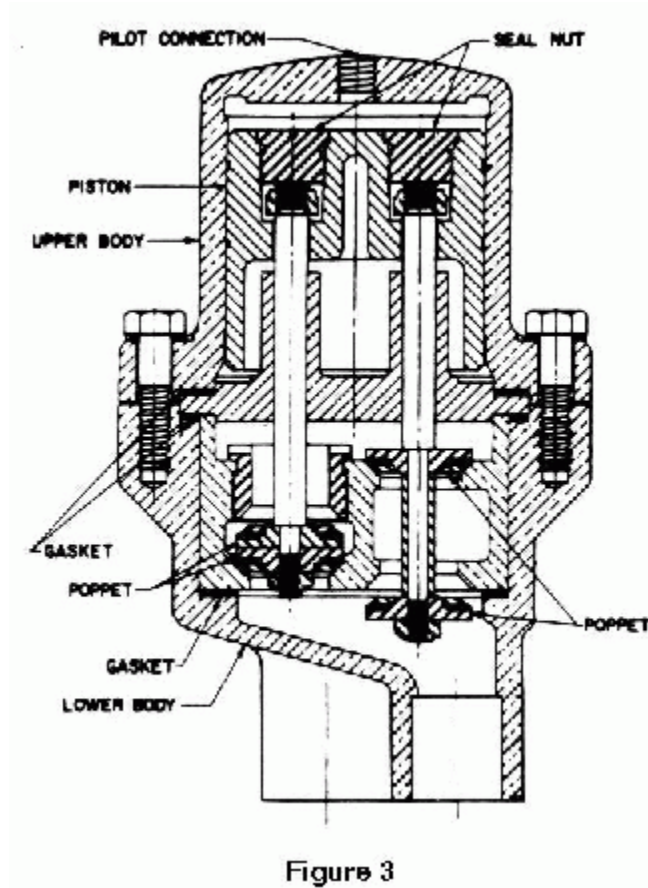
Like all other mechanical equipment and controls, the components which make up a reverse cycle system are subject to wear and damage, and it is necessary to service and/or repair them if they become inoperative. This article deals particularly with the problem involving reversing valves, and the solutions to these problems.

The complexity of the reverse cycle system can create the impression that the solution to various service problems is a great deal more difficult than the solution of similar problems involving the conventional refrigeration system. Actually, if the operating principles of reversing valves are fully understood, the service problems can be isolated and corrected in a normal period of time.

Formerly there were two basic types of reversing valves available; the poppet type so called because of the use of a poppet seating member, (see Figure 3) and the slide type valve in which the porting is controlled by a sliding member (see Figure 4).

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Poppet type reversing valve

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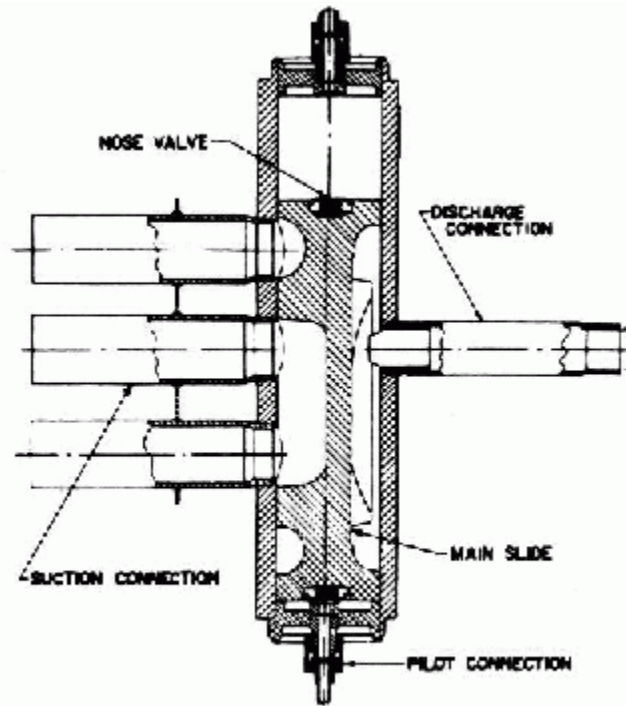


Figure 4

Slide type reversing valve

The operating principles, as well as the design and construction of the two basic reversing valve types differ considerably. Because of the differences, it is sometimes necessary to use a different approach to problems involving the slide type valve as compared to the procedures and techniques recommended for problems concerning the poppet type reversing valves.

However, since the poppet type is now considered obsolete for many years, it would be superfluous to discuss it at this time other than to quickly describe its operation. Because the poppet type has not been manufactured for many years no service procedure will be discussed here.

POPPET TYPE REVERSING VALVES

Operating Principles

Figure 5 schematically illustrates the poppet type reversing valve with the piston in the "down" position, the pilot solenoid valve de-energized and compressor discharge pressure imposed on the top of the piston.

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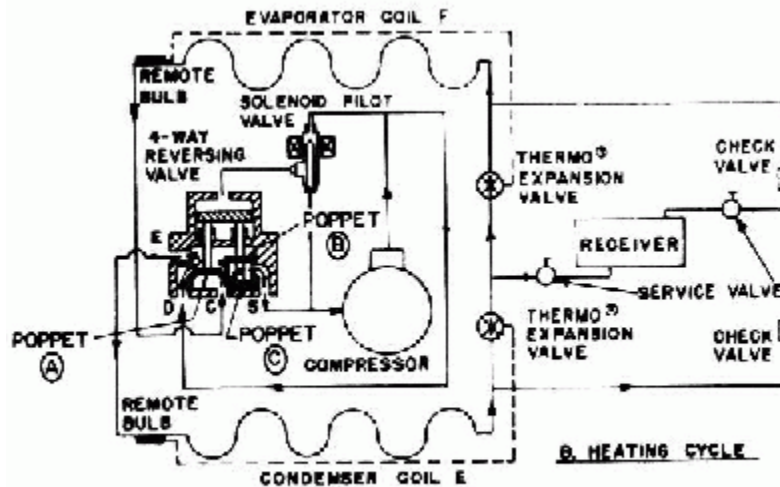


Figure 5

HEATING CYCLE — Reverse cycle refrigeration system using poppet type 4-way valve

With the reversing valve in this position and the "C" and "E" ports connected as indicated, compressor discharge pressure exists on both sides of the piston, and on top of poppets "A" and "B". Compressor suction pressure is imposed on the bottom of poppets "A" and "B". Poppet "C" is open. The pressure differential across poppets "A" and "B" is holding the valve in the "down" position.

When the reversing valve is called upon to shift from the "down" position, the pilot solenoid valve is energized, closing its compressor discharge pressure port and connecting the chamber on top of the piston to the compressor suction line. As this action occurs, the high pressure gas on top of the piston bleeds off through the pilot solenoid valve to the compressor suction line. An upward pressure unbalance will then exist across the piston. The force acting upward, due to the pressure differential across the large piston area, is sufficient to overcome the downward acting force, due to the pressure differential existing across poppets "A" and "B", so it shifts the valve to the "up" position.

Once the valve has shifted (see Figure 6) the high pressure underneath the piston bleeds off around the piston until compressor suction pressure exists on both sides of the piston. Compressor discharge pressure is now imposed on the bottom of poppets "A" and "C", and compressor suction pressure is imposed on top of poppets "A" and "C". Poppet "B" is open. The valve shift is completed and the pressure differential across the poppets is holding the valve in the "up" position.

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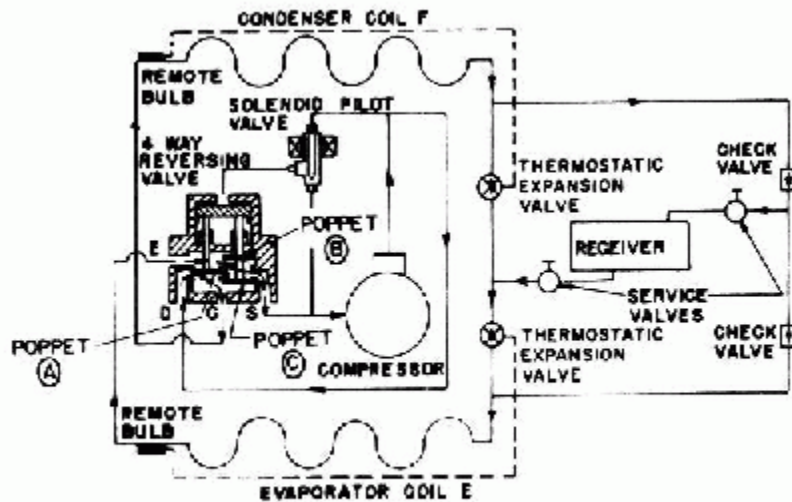


Figure 6

COOLING CYCLE — Reverse cycle refrigeration system using poppet type 4-way valve

This summary of the operational sequence clearly shows that the pressure differential across the piston of the reversing valve causes the valve to shift, and the pressure differential across the poppets holds the valve in the designated position.

SLIDE TYPE REVERSING VALVES

Operating Principles

In Figure 7 the system is on the heating cycle with discharge gas flowing through reversing valve ports "D" to "2" making the indoor coil the condenser. The suction gas is flowing from the outdoor coil (evaporator) through reversing valve ports "1" to "S" and back to the compressor.

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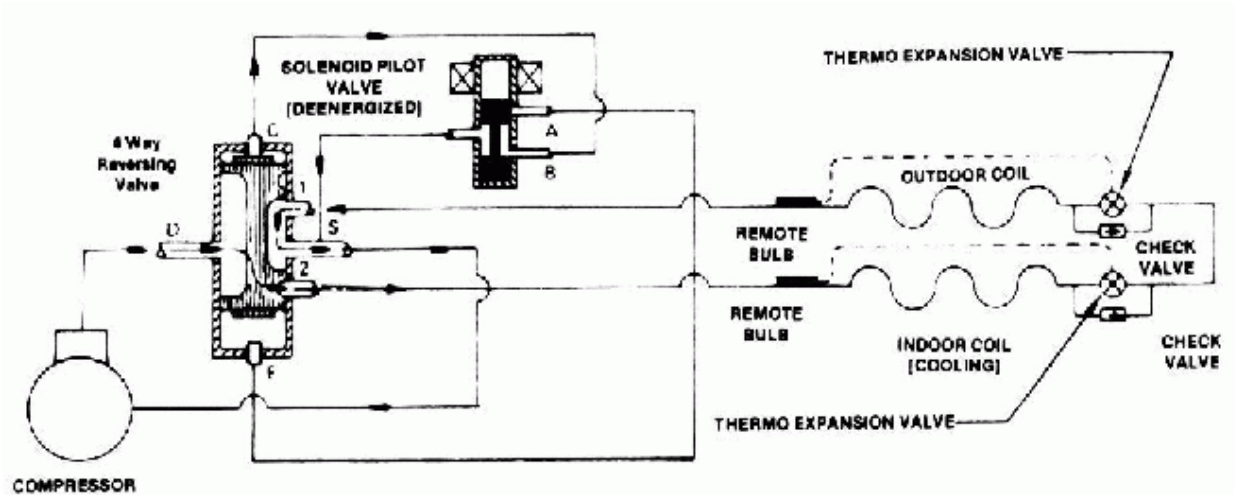


Figure 7

Heating Cycle

The 3-way solenoid pilot is de-energized with the slide positioned so as to open the "B" port and close the "A" port. The main slide is in the up position sealing off nose valve "C" and opening nose valve "E." Thus, nose valve "E" is isolated from the suction side by the pilot solenoid valve, and nose valve "C" is exposed to suction pressure through the pilot solenoid valve.

With the valves so positioned the controlled leakage of the high pressure discharge gas around the main slide builds up on the ends of the main slide. The area of the top end of the slide, less the area of nose valve port "C" is exposed to discharge pressure, while the area of nose valve "C" is exposed to suction pressure. The area of the bottom end of the slide and the area of nose valve "E" are both exposed to discharge pressure. Thus, the unbalanced force, due to the difference between discharge and suction pressures acting on the area of the nose valves holds the slide in the "up" position.

When the coil is energized the slide in the pilot solenoid valve raises, opening port "A" and closing port "B". With the pilot solenoid valve so positioned, the discharge pressure imposed on the bottom of the main slide and the area of nose valve "E" will bleed off through the pilot solenoid valve to the suction side of the system. An unbalanced force in a downward direction is then due to the difference between discharge and suction pressures acting on the opposite ends of the main slide and the nose valves.

This unbalanced force moves the main slide to the down position as shown in Figure 8 and the force unbalance across the area of the nose valves holds the main slide in the new position.

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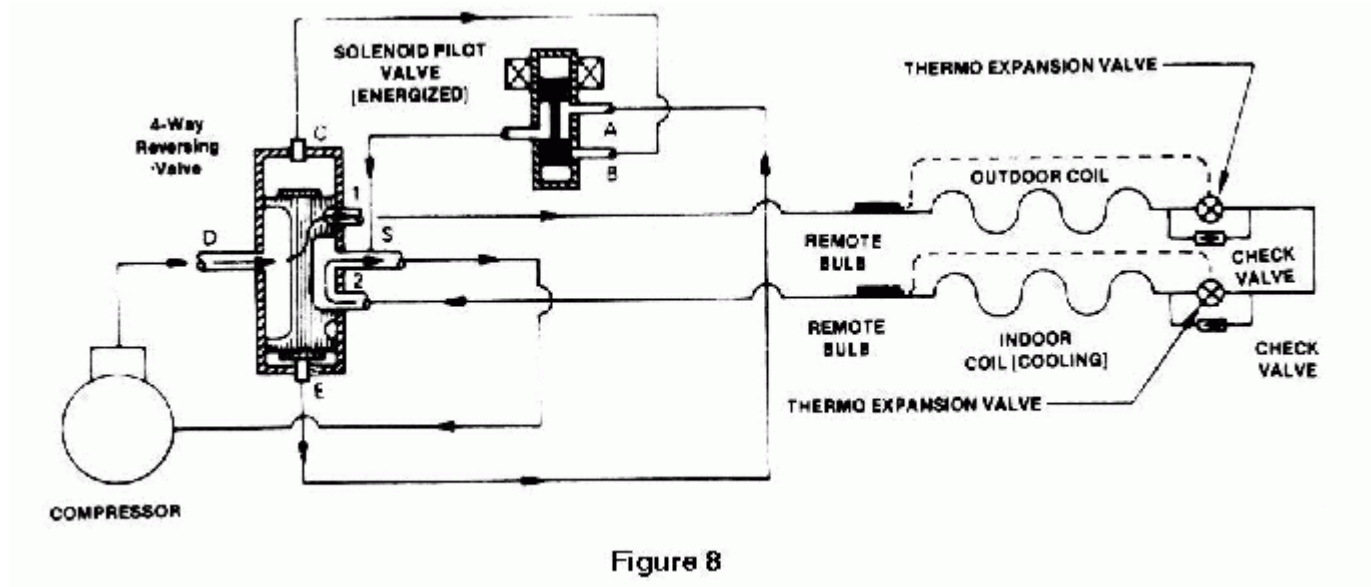


Figure 8

Cooling Cycle

The system has now changed over to the cooling cycle with the discharge gas flowing through reversing valve ports "D" to "1" making the outdoor coil the condenser with the suction gas flowing through reversing valve port "2" to "S", making the indoor coil the evaporator.



CAUTION:

Depending on the manner in which the reversing valve is piped into the system, power failure to the pilot solenoid valve coil will cause the system to "fail safe" on either the heating or the cooling cycle. In Figures 7 and 8 the valve is piped to fail safe on heating. In order to fail safe on cooling, the indoor coil would be connected to reversing valve port "1" and the outdoor coil connected to reversing valve port "2".

INTERNAL FACTORS AFFECTING VALVE OPERATION

The slide type reversing valve, being hermetic and primarily used by original equipment manufacturers on factory-built units, is not subjected to many of the problems to which the poppet type valves was exposed.

Since the main valve and the pilot are an integral unit, the problems relative to pressure drop, pilot line size, location, etc. between the main valve and the pilot are eliminated. Problems due to internal leakage and sticking due to foreign material are minimized since better techniques of assembly, higher degrees of evacuation and dehydration and high standards of overall system cleanliness are maintained on factory built-up installations. Thus the internal factors which affect operation of the slide type valve become design functions rather than service considerations, and as such, will not be covered here.

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Troubleshooting check charts will be discussed later in this chapter.

OPERATION OF RANCO "V" MODELS (V25-V26-V30)

The V valves are arranged for various nominal tonnage capacities for automatic operation of Heat Pump Air Conditioning systems, using temperature controls, in addition to the valves.

The series of V valves are hermetically constructed as a pressure differential operated, directional slide type, 2-position, 4-way reversing valve. Its operation is controlled by an energized or de-energized Solenoid Coil secured over the 3-way pilot valve with a lock nut, integral with the main valve.

The valve body is brass tubing, with internal parts constructed to operate at various capacities within the same valve body by using different diameter sized connection tubes according to tonnage and refrigerant applications.

The valves are instantaneous in reversing against running pressures, and operate wholly on pressure differential between the high and low sides of the refrigeration system under full pressure within these listed capacities.

The four (4) valve connection tubes are brazed to the system in the vertical position illustrated with the body of the valve on a horizontal plane which may be rotated to any angle around its horizontal axis.

The refrigerant gas path is schematically diagrammed through the main valve showing the "sliding port" at a position of rest over two tube openings as it transfers both coils from operating phases of cooling, de-icing and heating. See Figures 14 and 15.

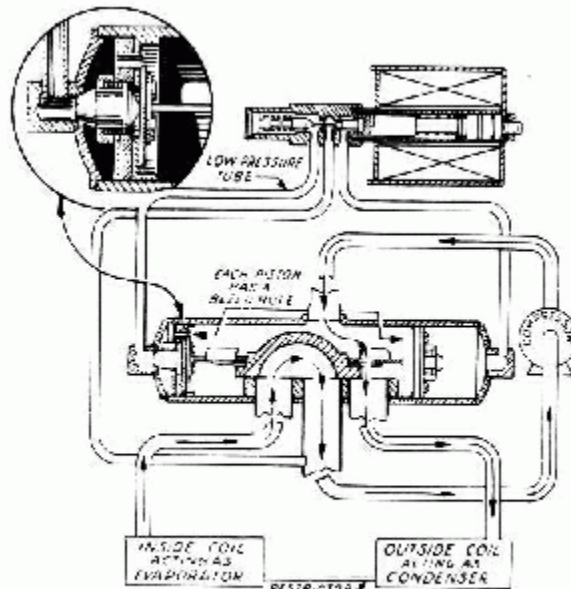


Figure 14 Courtesy Ranco Controls, Inc.

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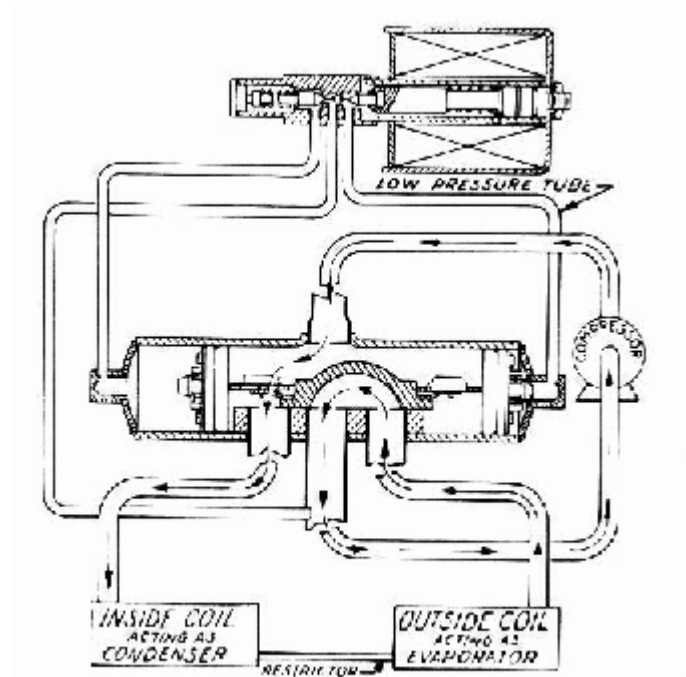


Figure 15 Courtesy Alco Controls, Inc.



NOTE:

The following description is of a system which energizes coil for HEATING and de-energizes coil for COOLING. Some systems energize coil for COOLING and de-energize for HEATING. Note which way your system works.

HEATING PHASE

1. Coil energized. Pilot valve—back port closed, front (plunger) port open. (Pilot valve ports connected to main chamber ends by capillary tubes.)
2. Gas flows out RIGHT end main chamber, pressure decreases. High pressure builds up in LEFT end chamber.
3. Difference in pressure moves slide bracket to RIGHT. In the reversing operation the slide port straddles one or the other of two openings. The suction tube is always open to the low pressure side of the system.
4. At end of stroke, pilot tube is closed as a path to the pilot valve so that high pressure refrigerant cannot flow back to suction tube.

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COOLING OR DE-ICING PHASE

1. While in, and during, the heating phase, both end chambers EQUALIZE in pressure.
2. Temperature control causes coil to DE-ENERGIZE. This causes pilot valve to respond.
3. Pilot and main valves reverse in just the opposite way as in the Heating Phase.

During the transfer period, there is enough by-pass to ports so that flow from compressor is never blocked. This prevents overloading the compressor due to excessive head pressure. There is an instant of hissing gas as pressures equalize in the system.

OPERATION OF CHATLEFF CONTROLS - MODEL CR

Although Chatleff Controls have several models of reversing valves, the Model CR illustrated in Figure 17 is a typical example.

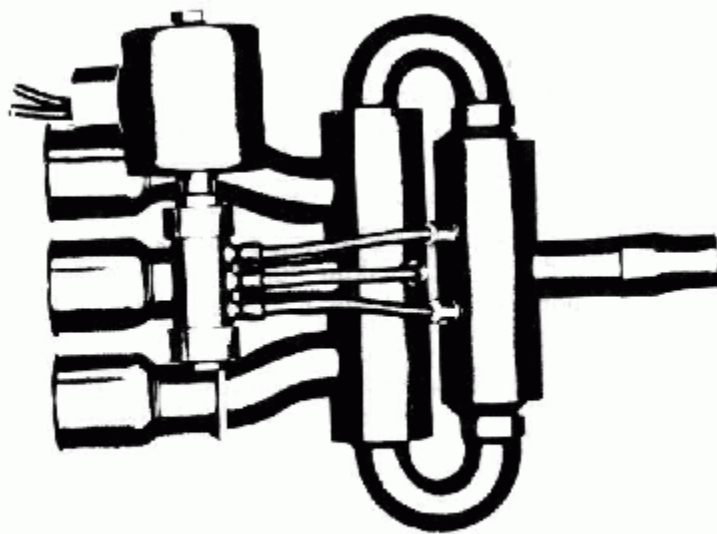


Figure 17

Courtesy Chatleff Controls

GENERAL DESCRIPTION

This is a valve that can be mounted in any position and has been designed to operate at pressure differentials from as low as 10 psi to as high as 400 psi. It will operate efficiently and reliably within this range and yield smooth performance even when subjected to velocity extremes. Its twin tube structure separates the control into two halves; a discharge or high temperature receiving chamber and a second chamber which primarily handles and controls the low temperature suction gas. Separation in this manner decreases heat exchange of the two temperature extremes by eliminating their close proximity as they pass through the valve. Control of flow is accomplished by a series of positive seating piston movements whose sequence is such that stoppage of flow never occurs, thus providing rapid changeover without

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interruption. The speed of this changeover is governed by the circulation requirements of the system. All seating surfaces within the main valve are Teflon on brass, which will efficiently seal at all load pressures and temperatures indefinitely since wear from friction is not a problem.

Although the following instructions are printed by permission of Chatleff Controls, they are good general instructions to be followed at any time for any type of 4-way reversing valves.

INSTALLATION

1. Inspect:
 - a. Look for shipping damage. A damaged valve will cost you hours of work and a freon charge.
 - b. Check the solenoid coil stem. A slant of no more than 2° out of line with the solenoid body has ruined the valve.
 - c. Look for dents. A dented solenoid stem, even a tiny dimple is enough to reject the valve. A body dent or dimple is not quite as serious. Ask yourself if you feel the dent on the body carried through, even slightly, to the inside. Your guess is probably correct. You can generally tell whether or not a blemish is merely a surface mar or a real dent. If you find a real dent, or feel you have found one, reject the valve.
 - d. Look in the ports. Sometimes a new valve may be placed in storage on some shop shelf. If a dust cover falls from a port, the valve may contain moisture or dirt or almost anything else you can imagine. Should you see anything inside except parts that are obviously the valve parts, reject it if they won't shake out. If you see corrosion, beware. Corrosion of valves left exposed to shop air is not uncommon. In many shops the natural moisture present is laced with welded gas fumes, flux fumes, cleaning chemical fumes, etc. All of these are highly acid substances and can initiate a corrosive action capable of ruining a valve left open on a shelf in a matter of a week, often less.
2. Before welding:
 - a. Prepare everything so that it is just right. Check all four joints for cleanliness and snugness of fit. Check the valve positioning. See that you have a can of water and four or five rags soaking in it.
 - b. Carefully and tightly wrap the valve body with a damp cloth making sure the junction of each port with the body has plenty of rag on the body.
 - c. Check your welding materials. Don't try to use up the scraps on this item. Use a good size stick, because they are easier to hold and to apply. Check your torch tip and flame. Adjust the flame so that it is just right for a nice fast job on the size tube you are using.
3. Welding:
 - a. Do one side of the valve at a time, but do all the joints on that side. This will vary from two to three. As soon as these are done, draw out a wet rag and wrap it over the hot joints.
 - b. Do the other joints and repeat with the rags.

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- c. Don't dawdle and don't rush. Speed is important because you aim to complete the job before you have raised the body temperature of the valve beyond 350°F. You have plenty of time barring an outright goof of some kind. Should you have a delay, stop and chill your hot joint immediately. Check the wetness of the rag on the body. It can be re-wet by squeezing a little water onto it. It doesn't have to be removed to be wet. Then start again.
- d. Slag: Use the welding material cautiously. Welding habits and practices that were perfect on cooling systems may not be good for heat pumps. Slag and run-ins that might be driven to a safe lodging point in a cooling system, will be dislodged and blown right back again in a heat pump.
- e. Leaks: Should a check of the system show a joint leak unless it is quite large, no special precautions are needed. Just use a hot, fast, and small flame and repair it. The amount of heat you place in the line is easily absorbed and dissipated before the valve body has become too hot to touch.

REMOVAL:

Before removing a reversing valve, check to see that you have one to replace it with. A system left open invites a repeat performance.

Please remember that in 1960 nearly 30% of the reversing valves removed were innocent. Most of them took the rap for a guilty check valve. Partially broken compressor reeds, ruptured expansion valves, plugged cap tubes also caused needless reversing valve exchanges.



CAUTION:

If you have a compressor burn-out, change the reversing valve. Don't rely on cleaning the system for cleaning this valve. You won't clean it. It is first in the line from the compressor discharge and as the compressor's electrical gear becomes cremated, it leaves the compressor. A wide assortment of carbons, tars, resins, acids, and miscellaneous chemicals are generated by the breakdown of the refrigerant, oil, and electrical insulation. These partially vaporized substances find a permanent resting place in the walls and parts of the nearest cooler object. They condense and etch themselves into the valve and parts with such vigor, cleaning operations are a waste of time. Remove the valve; then clean the system. The valve has made this easier, since it contains a good portion of the debris.

THINGS TO REMEMBER:

1. Remember the valve is expensive. It may be in warranty. Wrap it in a damp cloth and use care. If you burn the valve or mangle it, the cause of failure may be concealed or confused, and credit may not be granted. Reversing valves returned from the field are not scrap brass. Every single one is extensively examined, tested where possible, then dissected completely and the cause of failure determined. Such studies reveal flaws about many things in addition to the valve itself and has resulted in improvements of the entire conditioner.

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2. Tag the valve:

Credit for the valve is important to you and your firm. Frequently certain classes of failure are honored for replacement regardless of warranty. You can help insure this if you tag the valve with a comment on why you removed it.

3. Returning the valve:

Freight damage seriously interferes with returned valve analysis. Where possible, use the same container your replacement came in and pack the old valve back into the box on the spot. The box is also handy to jot down your reasons for removal.

TROUBLESHOOTING CHATLEFF REVERSING VALVES

System Failure:

The following list consists of a group of heat pump failure causes encountered for which reversing valves were erroneously blamed. It is not uncommon to find that as many as three valves (with the refrigerant charge, etc.) were put on a given system before the real cause of failure was uncovered. Causes are listed in order of their frequency.

1. Compressor runs but is not pumping:

- a. Compressor valves out or partially out.
- b. Shaft broken

2. Check valve trouble:

Liquid line checks stuck in either open or closed position. (An open check valve can cause compressor reed breakage.)

3. Liquid feeders stopped or restricted.

4. Expansion valve trouble:

- a. Frozen from moisture causing erratic performance
- b. Ruptured diaphragm causing loss of control.
- c. Stuck due to dirt

5. Control circuit trouble:

- a. Chattering contacts
- b. Burned out relay
- c. Open circuit
- d. Shorted circuit

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6. No refrigerant or low charge:
7. Over charge of refrigerant:

Valve Failure:

1. Burned out solenoid coil: (Always check this before removing valve)
2. Burned seats in valve: (Causes discharge of suction leakage)
3. Welded debris lodged in seats of valve: (Leakage form discharge to suction)
4. Varnish jam: (Always change reversing valve if compressor has burned out)
5. Bent solenoid stem: (Check this by removing coil and examining)

Things to Remember:

1. If the heat pump goes into a vacuum, the cause is not the reversing valve. The valve cannot blank off the suction line.
2. If the system is in a vacuum, the Model 'C' valves do not work properly. Model 'CR' valves will work but will seem to move harder than normal.
3. If the M.O.P.D. (Discharge-Section) is for some reason excessive (over 300 lb), the Model 'C' valves may refuse to go into heating. Model 'C' valves will return to cooling, regardless of M.O.P.D. Model 'CR' valves will operate both ways in excess of 400 lb M.O.P.D. at 15% low voltage.
4. The Chatleff valves are not slide type valves. They are full-seating. Occasionally on a shut-down system, a rapid tapping (motor boating) may be heard when the system is equalizing. This is normal but will not occur every time. The sound is caused by a pulsing member in the valve being moved by the equalizing flow of gas.
5. Delicacy: Reversing valves look rugged and are rugged to inside forces. They may mislead you by this look of weight and strength. When you hold in your hands 6 pounds of awkward-looking valve, you hold 6 lbs. of carefully machined and balanced parts. The valve must be capable of lifting its seats easily against 400 psig of gas and diverting this powerful stream into another line. It must do its job quickly, quietly, without strain, and repeat the job at least a million times. Yet it must not leak. It must also accomplish this action with a gentle force from a small electric coil. The accuracy required for this is the same as the accuracy for making an expansion valve, but far more difficult to achieve, since the parts are hundreds of times as big. If you drop a valve, you may ruin it. A twist is often essential to straighten the valve. Do not use the valve as a lever to straighten itself. You might warp a body slightly or bend a solenoid stem.

Most of the modern day residential (central system) and small commercial heat pumps are of the air to air variety. However, when a water cooled condenser is used in the system, it is necessary to add additional control devices to protect it against freeze-up during the defrost and/or heating cycle because the condenser is used as a source of heat and temporarily becomes an evaporator. With the advent of more and more solar systems—water to air heat pumps will become more popular.

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VARIATIONS IN HEAT PUMP SYSTEMS

Figures 18 and 19 show a reverse cycle system using an Evaporator Pressure Regulator, connected to the condenser, which is used to prevent freeze-up of the water flowing through the condenser during the defrost cycle. The regulator must be by-passed by a check valve which passes the hot gas flow to the condenser when the system is returned to the cooling cycle. In addition, a solenoid water valve must be used to bypass the condenser water regulating valve, permitting water flow during the defrost cycle.

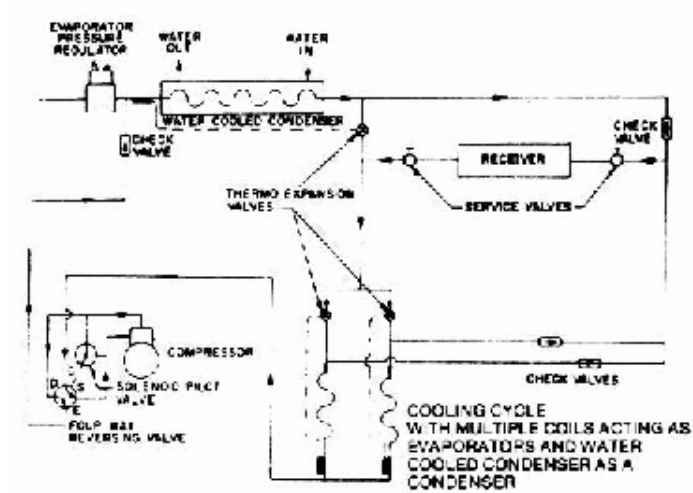


Figure 18

Reverse cycle system using an evaporator pressure regulator on the condenser [cooling cycle]

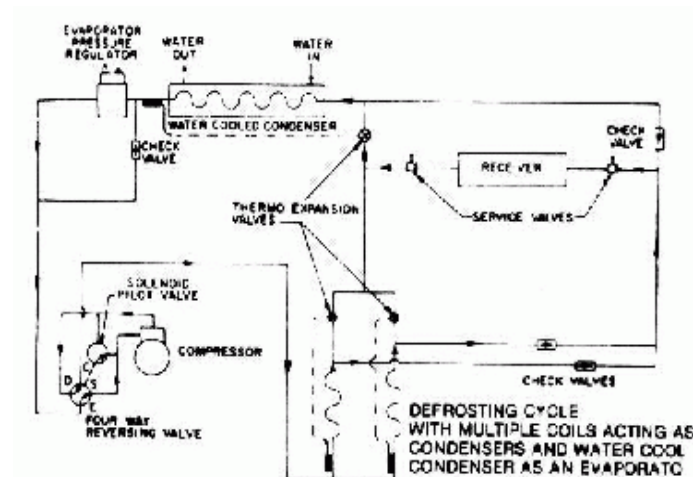


Figure 19

Reverse cycle system using an evaporator pressure regulator on the condenser [heating cycle]

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Figures 20 and 21 show a reverse cycle system using a Constant Pressure Liquid Expansion Valve feeding liquid refrigerant to the condenser when it is used as an evaporator during the defrost cycle. The Constant Pressure Liquid Expansion Valve must be adjusted to prevent the suction pressure from falling below the pressure corresponding to the refrigerant saturation temperature of 33°F during the defrost cycle. This valve must be by-passed with a check valve permitting condensed liquid refrigerant to flow into the receiver during the cooling cycle. In addition, the connection at the receiver, to which the Constant Pressure Liquid Expansion Valve is connected, must have a dip tube to insure adequate solid liquid supply to this valve. It is also possible to run two separate lines, one from the check valve to the top of the receiver and the other from the Constant Pressure Liquid Expansion Valve to the bottom of the receiver. A Solenoid Water Valve must also be used to by-pass the condenser water regulating valve and it is necessary to have an excess amount of water flowing through the condenser during the defrost cycle, which will absolutely guarantee boiling off all of the refrigerant being fed by the Constant Pressure Liquid Expansion Valve, to prevent flood-back of liquid refrigerant to the compressor, and the resulting damage.

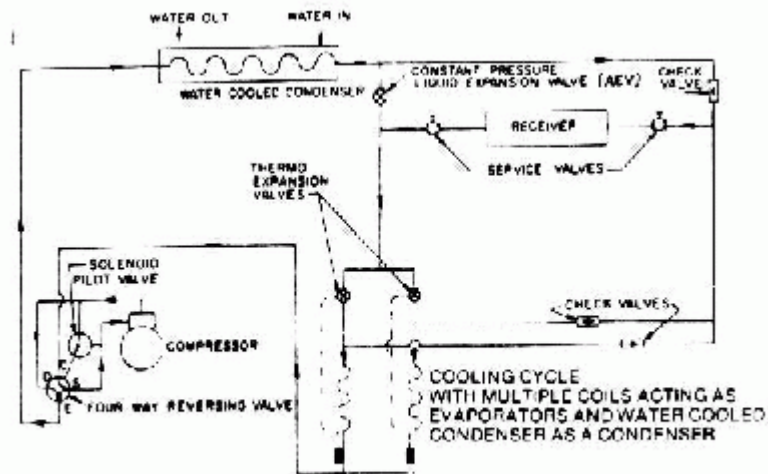


Figure 20

Reverse cycle system using a 4-way reversing valve and a constant pressure liquid expansion valve [A.E.V.] [cooling cycle]

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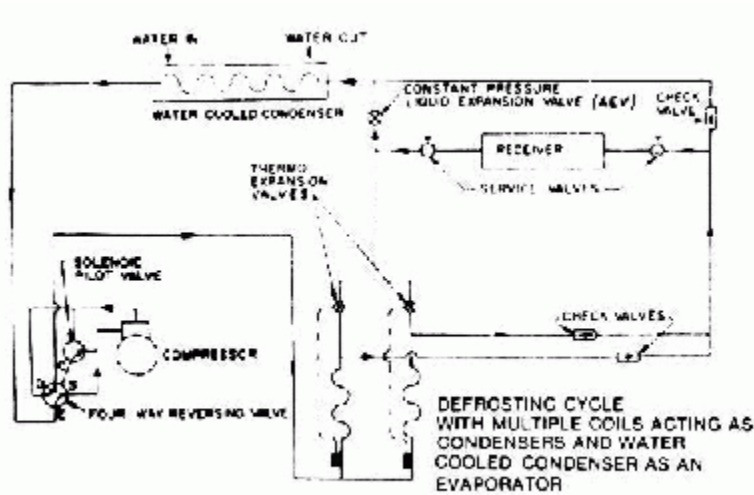


Figure 21

Reverse cycle system using a 4-way reversing valve and a constant pressure liquid expansion valve [A.E.V.] [defrosting cycle]

As a rule, large commercial and industrial heat pump applications are custom tailored while household and small commercial heat pumps are turned out production line style, and thus the remainder of this article shall be devoted to these production type models.

RESIDENTIAL HEAT PUMPS come in the same range of tonnage as residential air conditioning and for good reason. The residential heat pump is a direct substitute for the cooling system while at the same time takes the place of the central heating system as far as possible into the winter season. Most residential heat pumps are of the air to air type.

How far into the heating season that the heat pump will go and take care of the heating load depends on a number of things, i.e.:

1. Horsepower of heat pump
2. How well the house is insulated
3. Geographical location
4. Outside temperature, etc.

Experience has shown that supplemental heat (from whatever source) will be needed whenever the balance point (heat leakage vs. heat input) of the building has been exceeded.

A heat pump can pick up heat from the outside air as long as there is heat in the air to be picked up. However, the lower the temperature, the lower is the heat content of the outside ambient conditions, so at some point (most likely between +30°F and +10°F) the heat pump cannot pick up enough heat energy to do the job, because it just is not there to be obtained. At this point supplemental heat must be added.

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With supplemental heat, most heat pump manufacturers claim that their equipment will take care of conditions down to approximately -20°F.

Residential and small commercial heat pumps are manufactured in two basic designs, (1) the self contained package and (2) split system. Both being of the air to air type.

THE SELF-CONTAINED PACKAGE is, in essence, an overgrown large-capacity window unit. Both low and high side, along with all connecting tubing, controls, valves, and safety devices, are all contained within one single housing. Depending on design this may be installed in an attic, mounted in a closet, or hung from the basement's ceiling. Ducts are then extended to draw and blow the supply and return air as needed.

THE SPLIT SYSTEM is just like its air conditioning counterpart i.e., the inside coil with appropriate valve and controls would be mounted as a furnace is now mounted inside, and the high side components are grouped together in one package or "dog house" and installed in the same manner as the compressor and its condenser of the central air conditioning system on the outside.

The reason for the above basic review of the two main types of residential heat pumps will become apparent as we proceed.

TYPES OF HEAT PUMP SYSTEMS

Heat pump systems come in a variety of expansion device configurations, i.e.:

1. Two thermostatic expansion valves.
2. Two cap tubes.
3. One thermostatic expansion valve and one cap tube.
4. One common expansion valve (no cap tube) with uniflow.
5. One common expansion valve (no cap tube) with bi-flow.

Condition 1), that of two expansion valves using two check valves could be on a deluxe package or split system. See Figures 22 and 23. Note flow through reversing valve.

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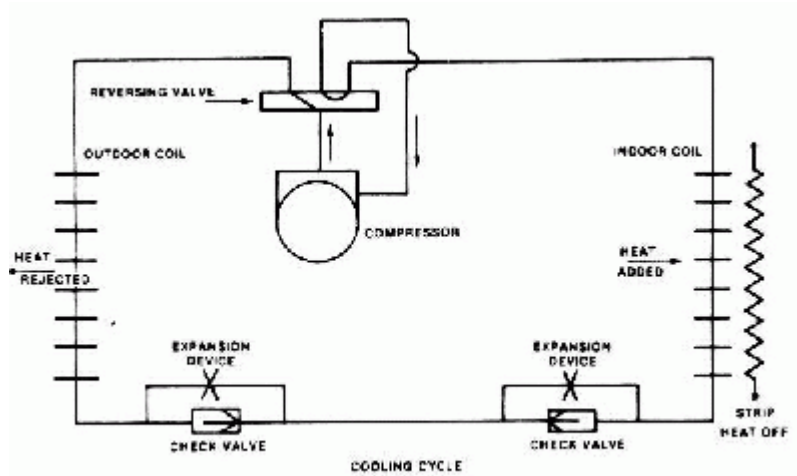


Figure 22

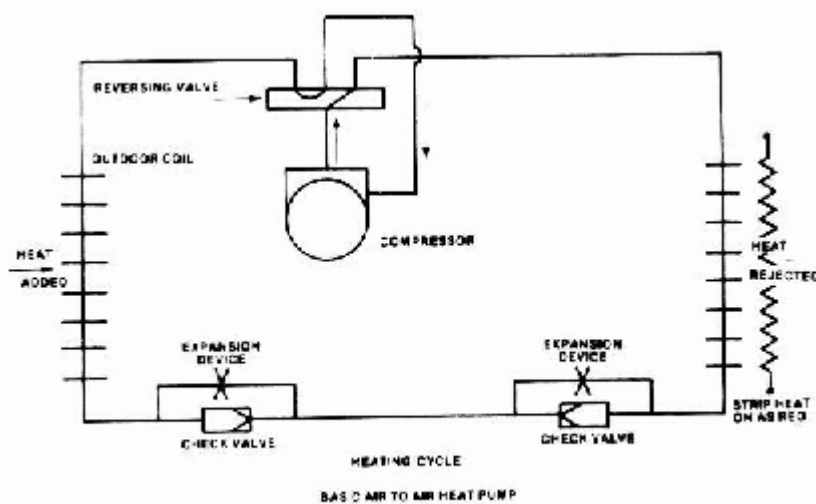
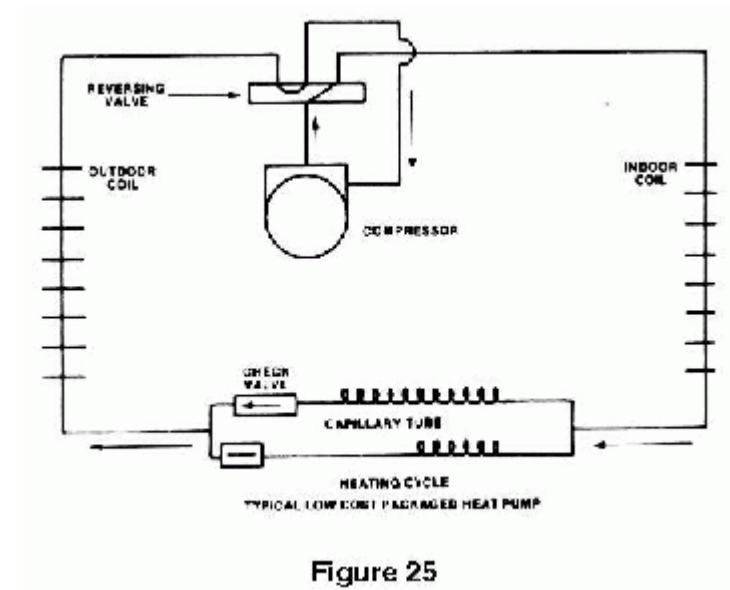
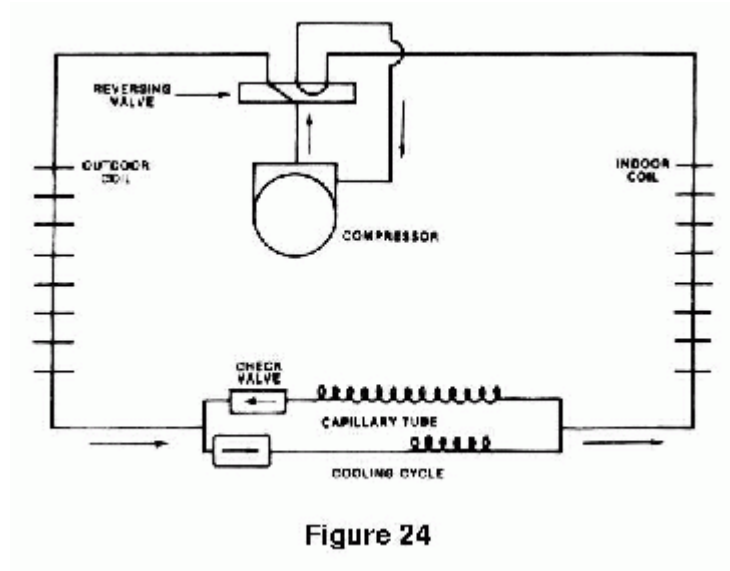


Figure 23

Condition 2) that of two cap tubes using some type of check valve arrangement which causes flow to go through a larger cap tube on heating and a smaller cap tube on cooling. See Figures 24 and 25. Note flow through reversing valve.

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Condition 3) is probably the most popular type of heat pump i.e.; the split system air to air, one TEV on the outside coil and a cap tube on the inside coil. See Figures 26 and 27. Note the flow change in the reversing valve.

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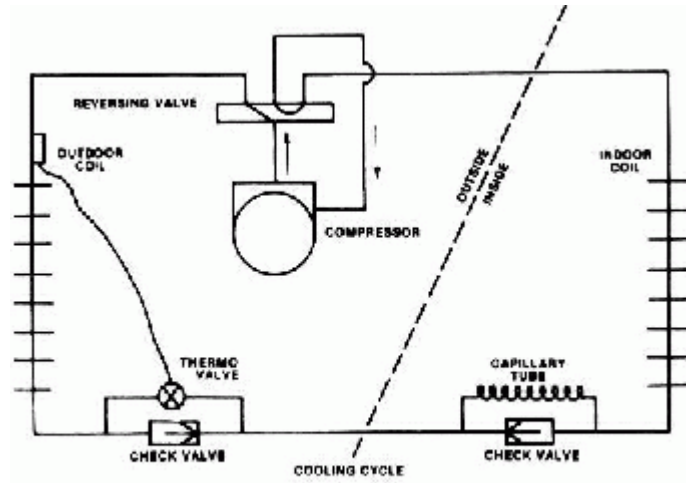


Figure 26

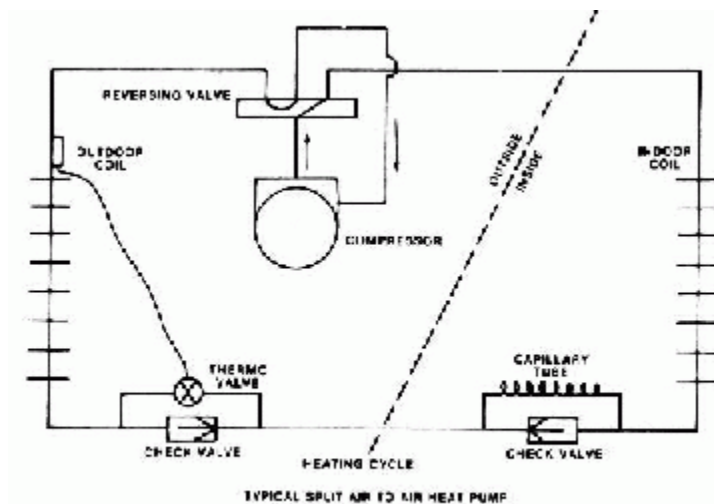


Figure 27

Why is this a popular type? The use of a cap tube keeps down some expense. The use of a TEV on the outside coil gives controlled flow with all types of outside weather. Being a split system it can be set up with any reasonable length of liquid and suction lines. No extra duct work is necessary, just use the regular furnace duct work. Note—flow pattern in reversing valve.

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In conditions 1) and 3) there is a thermostatic expansion valve on the outside coil, and some manufacturers of heat pump compressors have expressed concern over the ability of the outside TEV to operate with a low enough superheat.

These hermetic compressors have been "beefed" up to withstand the extra heavy duty imposed by heat pump systems and need all the cooling effect they can get from the returning low superheated, wet, suction gas.

To this end the major manufacturers of Thermo Expansion Valves have offered to the heat pump manufacturers who use these heavy duty hermetic compressors, TEV's that will work on the outside coil with a very low but controlled superheat. Thus with controllable wet gas assured to the heat pump compressor, total system long life is also assured. A special charge in the power element makes these special heat pump TEV's. Note-Be therefore advised and do not change out a TEV on an outside coil with a standard TEV, as it may well be a special TEV with a low superheat range built into it.

Condition 4) is an old time idea (1930's - 40's) that has been tried again in the 1970's. See Figures 28 and 29. The idea here is to use one common expansion valve that feeds both the inside and outside coils.

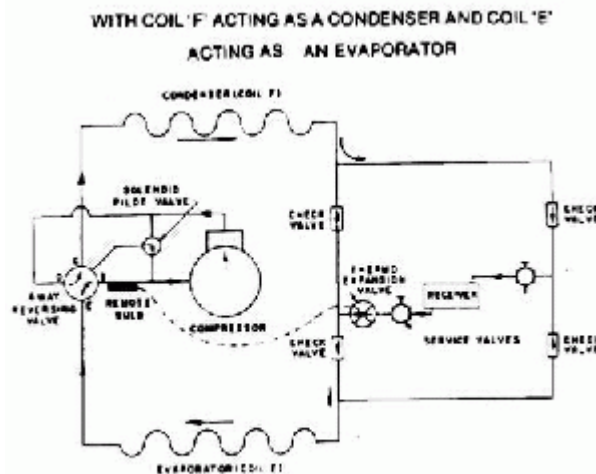


Figure 28

Reverse cycle using a 4-way reversing valve [cooling cycle] with one common TEV [Uniflow]

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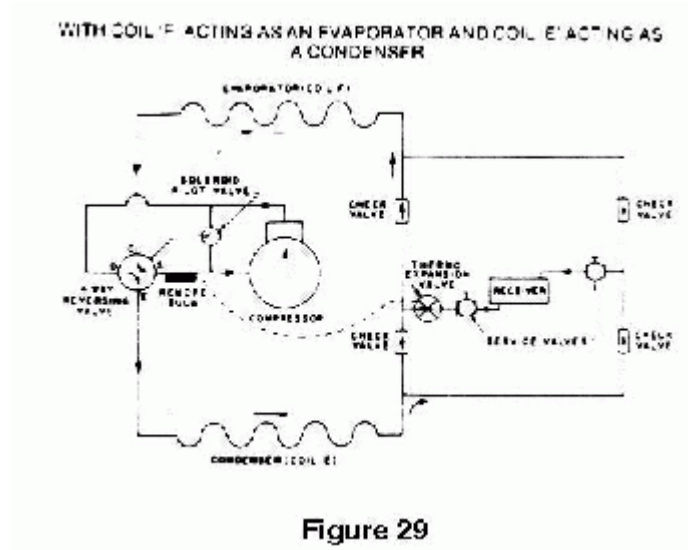


Figure 29

Reverse cycle using a 4-way reversing valve [heating cycle] with one common TEV [Uniflow]

Notice that the sensing bulb is attached to the common suction line. The flow through the valve is always in the same direction. Also, the external equalizer line must be connected to the common suction line. Again the flow pattern should be noted as the reversing valve shifts.

Condition 5) is rather new to the heat pump industry. This consists of one common expansion valve with a two or bidirectional flow. In other words the flow through expansion valve reverses every time that the 4-way valve changes over. There are certain standard expansion valves on the market that will accept bidirectional flow as long as they are of the external equalizer type. See Figure 30.

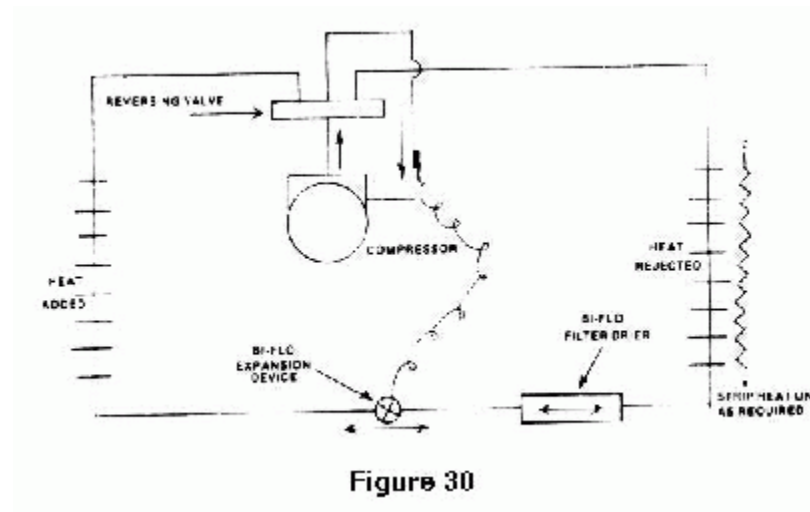


Figure 30

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Here again with a single expansion valve, care must be exercised to make sure that the sensing bulb of the thermo valve is located on the common suction line located between the 4-way reversing valve and the compressor.

This brings up the need for a bi-directional filter drier and it is very possible that from this date on you will see, "special" bi-directional or reverse flow filter dryers appearing on OEM equipment.

This bi-directional filter drier will be an OEM item for the next couple of years before it will appear at the wholesaler counter.

SYSTEM VARIABLES

Figure 31 is used to indicate the many variables that might show up on a heat pump system.

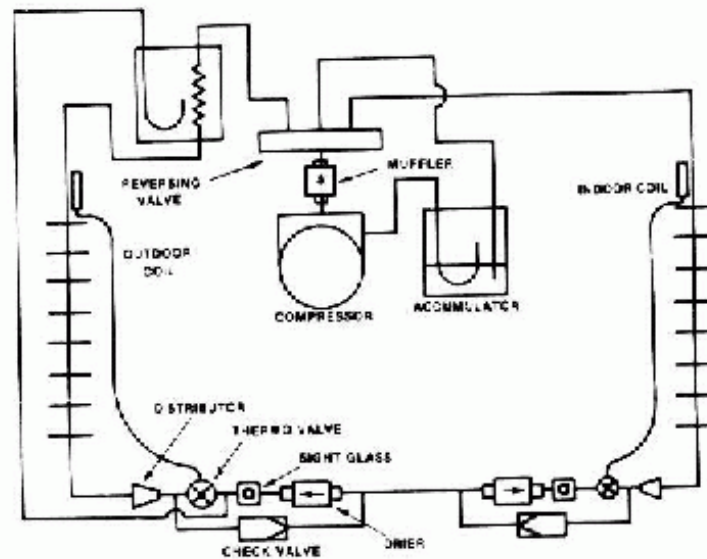


Figure 31

1. Expansion valve
2. Sight glass
3. Filter drier
4. Distributor
5. Check Valves
6. Accumulator
7. Charge Modulator
8. Muffler

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Any of these so called accessories are not 100% necessary for the proper operation of a heat pump, in fact all eight of the above named system parts could be eliminated and the system could be made to operate with just the addition of a cap tube.

The point that is to be made here is the one valve that is absolutely necessary for proper operation is the 4-way reversing valve.

Some attempt has been made to eliminate the reversing valve by various manufacturers by using dual systems i.e., one system for heating and one system for cooling. At this point in time these dual systems have been withdrawn from the marketplace. This is not to infer that something else won't appear in the marketplace at a later date.

There is in fact one slightly different type unit that has been and still is very much in the heat pump market. This is the Hi-Re-Li System. Although different in the fact that it uses neither a conventional thermostatic expansion valve or cap tube it does still make use of a 4-way reversing valve!

The main difference between conventional heat pumps using a reversing valve, and the Hi-Re-Li system is a special arrangement or cluster of check valves (all in one housing) and an expansion device that operates from the temperature (subcooling) on of the liquid line. See Figure 32.

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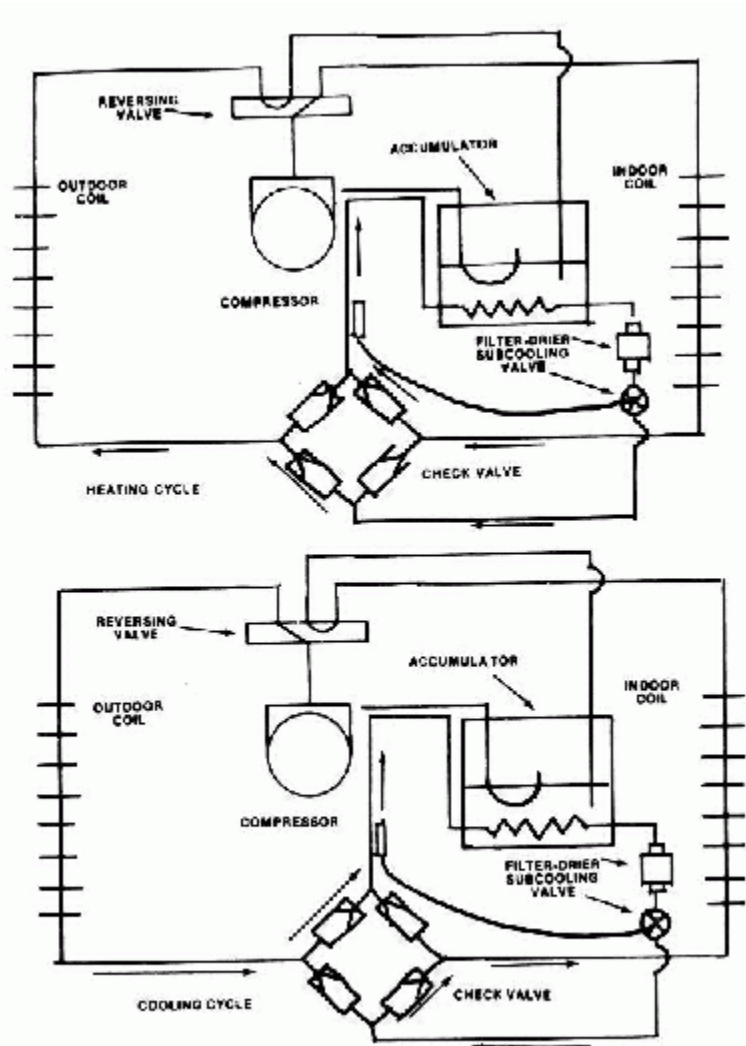


Figure 32

Westinghouse Hi-Re-Li Split System

The cluster of check valves takes care of re-arranging the flow pattern between heating and cooling and the subcooler valve meters flow (in place of a standard type thermostatic valve) in response to the liquid line temperature instead of superheat in the suction line as would a regular thermo valve.

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SUMMARY OF 4-WAY VALVE SERVICE

Know the Operating Sequence

- A. While in, and, during an operating phase (i.e. heating) both ends of the main slide body become equalized with high pressure. There are three principle operating phases i.e.: 1) heating, 2) cooling and 3) defrosting.

Formerly all heat pumps were designed to fail to the heating mode, that is, if the pilot solenoid coil were to become inoperative for any reason, the 4-way valve would revert to its heating position.

This is not necessarily so today. Some manufacturers of heat pump equipment so pipe the 4-way valve that it will fail to the cooling mode, especially if the units are to be sold in the southern states. It can generally be assumed that the single tube is always receiving hot discharge gas and the center tube of the three tube cluster is always connected to the suction line.

It is the two outside tubes of the three tube cluster that can be piped one way or the other, i.e., either to fail to heating or to cooling. This the manufacturer usually decides for himself. If you are building or converting a heat pump of your own, the decision becomes yours.

- B. When it becomes desirable to change the operating phase (i.e. heating to cooling) the solenoid pilot valve will—
1. Energize if it has been de-energized.
 2. De-energize if it has been energized.

This will immediately open a path from the large volume chamber of the reversing valve through the pilot to the middle tube or suction line.

- C. The high pressure that is in the large volume chamber immediately dumps into the suction line via the pilot valves.
- D. With suction pressure now on one side of the
1. slide cylinder, or
 2. poppet cylinder, and the original high pressure on the other side you will have an immediate shift of the cylinder or slide.
- E. With the shifting of the cylinder there should be a "whooshing" or hissing sound as the pressures reverse but nothing more. The system pressures as noted on your service gauge manifold will tend to jump and then recover almost immediately as the reverse flow in the system becomes normal.
- F. The defrost cycle will differ from the cooling cycle.

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Know What Troubles Can Effect the 4-Way Valve

- A. Make sure you don't have a system problem that would effect the 4-way valve action, i.e.
 1. Loss of charge or overcharge.
 2. Compressor not pumping (turns OK).
 3. Leaking check valves.
 4. Defective electrical equipment.
 5. Check manufacturer's operating specifications
 6. Valve damaged. Check for dents, deep scratches, cracks.
 7. See if solenoid coil enclosing tube is plumb. Two (2) degrees off center and the solenoid will not seat properly.
 8. Watch out for flattened tubing.
 9. Plugged drier or restricted liquid line.
 10. Expansion Valve inoperative or plugged cap tube.
 11. Compressor burn out (valve must be removed).
- B. After assuring oneself that no system problem exists then check out the reversing valve.
 1. Check solenoid pilot coil-is it burned open-shortened?
 2. Is the enclosing tube (stem) bent 2 degrees or more?
 3. Main valve stuck in one position—works one way but not the other.
 4. With the electrical system OK, make the coil pull test.

Conclusion

1. If the coil pull test does not respond correctly, change the pilot assembly.
2. If the coil pull test seems OK but main valve fails to slide properly-change out the main valve.
3. The "touch test" may be made at this point before removing anything.
4. Regardless of reason for failure the valve will have to be changed.

Removing the Reversing Valve

1. Do you have an exact replacement?
2. Do not remove by heating except as a last resort. If the valve is in warranty, burning it out may destroy the reason for failure and void the warranty.

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3. Tag the removed valve for easy identification.
4. Plug all openings on valve and system.
5. Pack thoroughly for return to factory. Freight damaged valves may be denied warranty.

Installing a New or Replacement Valve

1. Check for shipping damage
 - a. Dents, deep scratches, cracks
 - b. Flattened tubing
 - c. Slant of solenoid coil enclosing tube. It should be plumb with its base.
2. Use wet rags around body and tubing
3. Do not use oversized torch tip
4. Direct flame away from valve body
5. Use as low temperature braze as local code will permit, preferably phosphorous bearing alloys that require no flux.
6. Keep everything clean, it only takes on tiny bit of scale, flux, braze, metal dust, filing, or lint to clog up the pilot valve.

INSTALLING THE REVERSING VALVE

The reversing valve may be mounted in either a horizontal or a vertical position, without detracting from the proper operation of the valve.

However, after years of experience by many manufacturers of heat pump systems who have mounted the 4-way reversing valve in every conceivable position, with all types of tubing configurations, and system oil concentrations it is generally accepted by OEM's that a horizontal mounting position is recommended to insure optimum operation in a system. The valve may be oriented to any angle of rotation around its horizontal axis, without affecting the operation.

If the valve is mounted vertically in a "dirty" system, there is a possibility that the strainers in the ends of the valve body may become clogged, due to the settling out of dirt or other foreign matter, which could seriously inhibit the proper reversing action of the valve, also if the solenoid pilot hangs "down", rather than "up", when the main slide body is horizontal, the possibility of dirt or heavy oil concentration settling into the solenoid pilot is always a possibility.

1. Install the valve in a location on the system, where it will be subjected to minimum vibration.
2. Avoid rough handling of the valve during installation. If the valve body proper or the capillary tubing, is dented or flattened, the reversing action of the valve may be impaired, or stopped completely due to binding of the "sliding port" assembly.

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3. Protect all tubes to the valve and system against the entry of foreign matter, such as copper oxide flakes, metal filings, dust, etc. when brazing the valve into the system.
4. It is recommended that all connections be made using "fluxless" brazing techniques.

However if flux is used, care must be taken that it does not enter the system, as flux residues such as fluorides and borates are injurious to refrigeration systems.



CAUTION:

Keep valve body WET while brazing. The use of wet rags is highly recommended.

Body temperature must not exceed 250°F for brass bodied valves or 300°F for steel bodied valves, otherwise possible damage to the pilot needle valves, internal synthetics, or actual body warpage may occur.

REPLACEMENT OF ORIGINAL EQUIPMENT

Never use heat to remove the pilot solenoid or slide valve if at all possible, especially if the valve is in warranty. The large amount of heat necessary to "un-braze" will probably cover up the original reason for failure and thus nothing is left for the manufacturer to determine cause of failure or to adjust warranty.

Do all patching of tube stubs (proper length, proper swaging) on the work bench before replacing the new 4-way valve back into the system, then follow the above mentioned installation instructions.

SERVICE INSTRUCTIONS

Table A covers the basic problems that may be encountered, symptoms indicated by the system and recommended procedures to be followed to correct the cause of the problem on systems utilizing slide type reversing valves.

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Table A

| SYMPTOM: System Operating Cycle Cannot be Reversed - Reversing valve will not shift | |
|--|--|
| PROBABLE CAUSE | RECOMMENDED SERVICE PROCEDURES |
| 1. Pilot solenoid valve not operative | a) Check control circuit for loose connections low volt age, faulty switches, etc. Repair or replace defective controls. |
| | b) Check the pilot solenoid valve coil. If burned out, replace with new coil. |
| | c) Check the pilot solenoid valve for incorrect assembly of parts. Reassemble according to the manufacturer's instruction. |
| 2. Dirt, sludge, or products of a compressor burn-out causing the valve to stick in one position. | a) Where the system has had a mild burn-out, follow the normal clean up procedure. If the reversing valve sticks after the system is placed in operation again, tap the valve lightly and attempt to free-up alternately energizing and de-energizing the pilot solenoid valve. If this procedure results in the reversing valve operating correctly, cycle the valve a sufficient number of times to be sure the problem has been corrected. If this procedure does not free-up the valve, it should be replaced. |
| | b) Where the burn-out has been severe and the by-products of the burn-out are known to be throughout the system, the reversing valve should be replaced. |
| | c) Where the system has not suffered a burnout, but where there is reason to believe that the system is dirty and contains foreign material, the "Tapping-cylinder procedure" described in 2a above should be used. |
| SYMPTOM: Reversing Valve will shift, but by-pass leakage exists as evidenced by high compressor suction gas temperature and/or high compressor suction pressure | |
| PROBABLE CAUSE | RECOMMENDED SERVICE PROCEDURE |
| 1. Leakage through compressor discharge valves. | a) Close the king valve in the system liquid line and pump the system down to as deep a vacuum as possible. Close the compressor suction valve and observe the compressor suction pressure. If the vacuum holds, the compressor valves are satisfactory. |
| 2. Leakage through check valves or open by-pass lines | a) Leakage of this type can generally be detected by an abnormal temperature difference across the check valve. Replace the leaking valve. |
| 3. Internal leakage through the reversing valve. | a) Check the temperature rise across the reversing valve suction connection against the unit manufacturer's data. If the temperature rise is excessive and remains so after repeated cycling of the reversing valve, the valve should be replaced. |